Supplementary Information

Spintronic Filter via p Typed Polaron state in Photoelectron Conversion Integrating Devices

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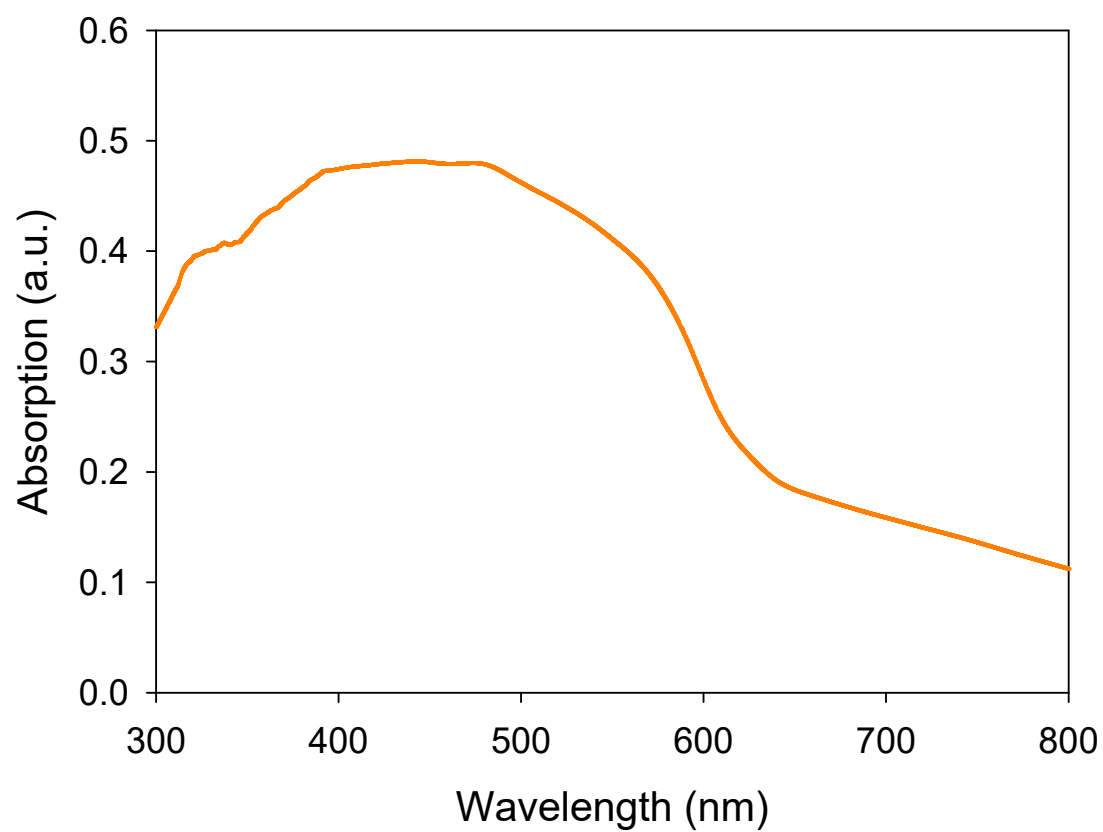**Keyword: polaron, spintronics controlling system, water splitting devices, surface state, Cu_2O, charge mobility**

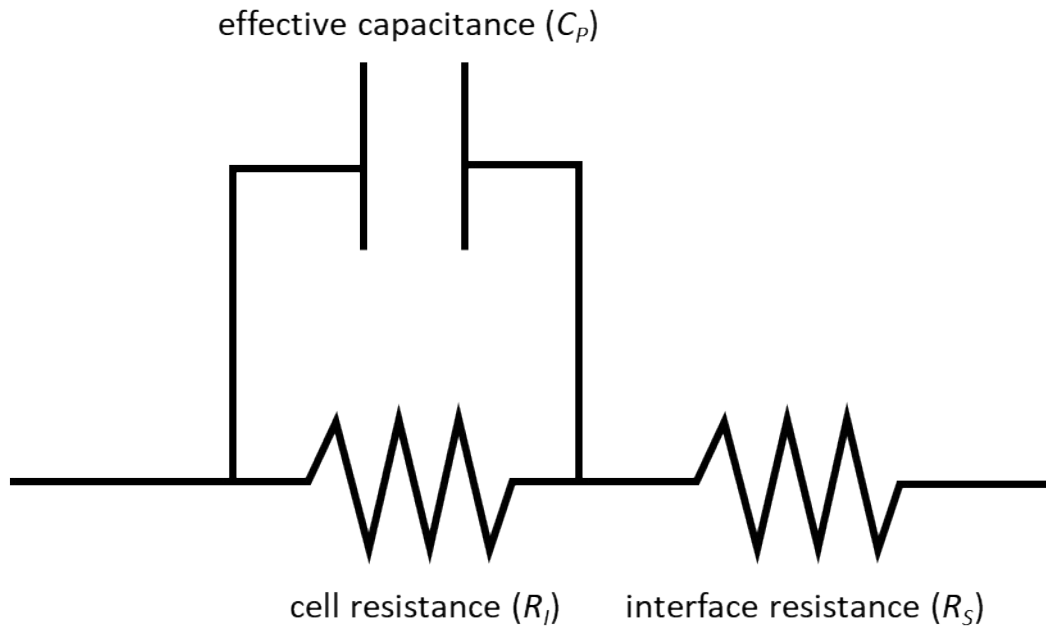Fig. S1 Absorption spectrum of CuO-Cu$_2$O nanocubes on ITO substrates.

Fig. S2 Equivalent circuit diagram of CuO-Cu$_2$O nanocubes photocathode water splitting devices for modeling the electrochemical cell of CuO-Cu$_2$O nanocubes photocathode in a two-electrode configuration at an optimal potential bias (R$_S$, interface resistance between electrode and electrolyte; R$_I$, cell resistance; C$_P$, effective capacitance) via AC impedance.
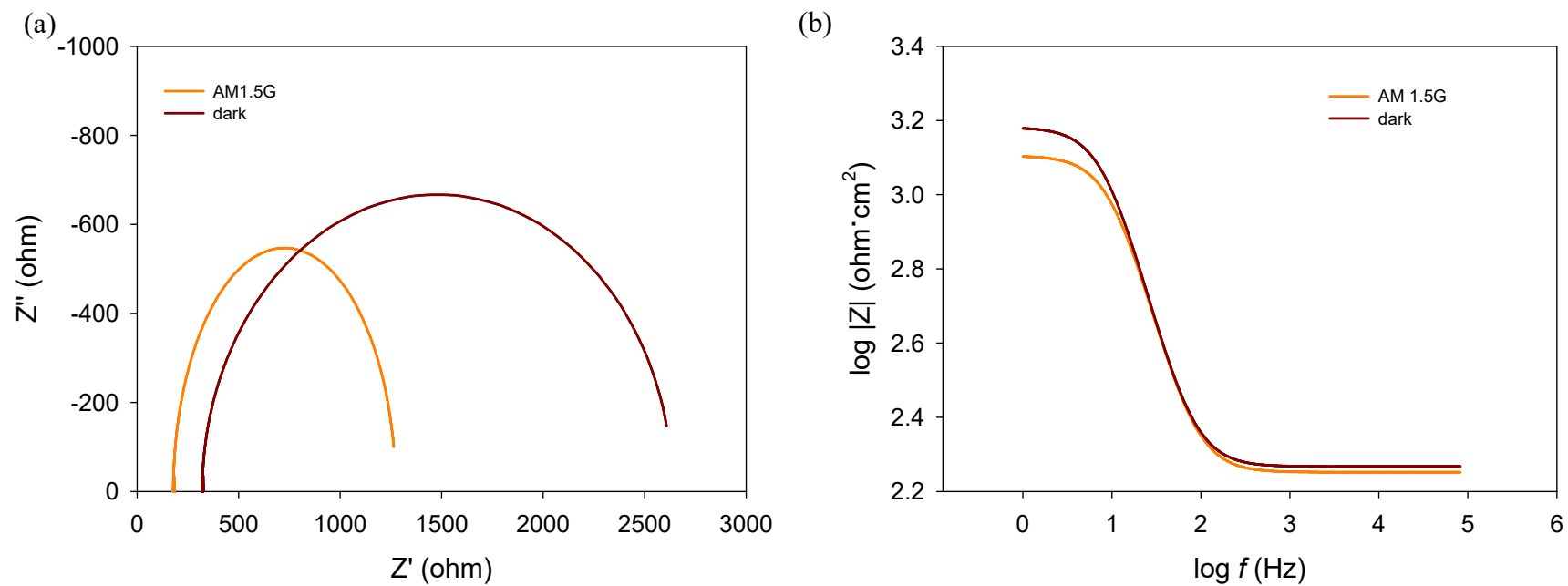
Fig. S3 Nyquist diagram (a) and Bode plots (b) of CuO-Cu$_2$O nanocubes photocathode under AM 1.5G irradiation, at 0.98 V in a two-electrode configuration in 1 M KHCO$_3$ electrolyte.
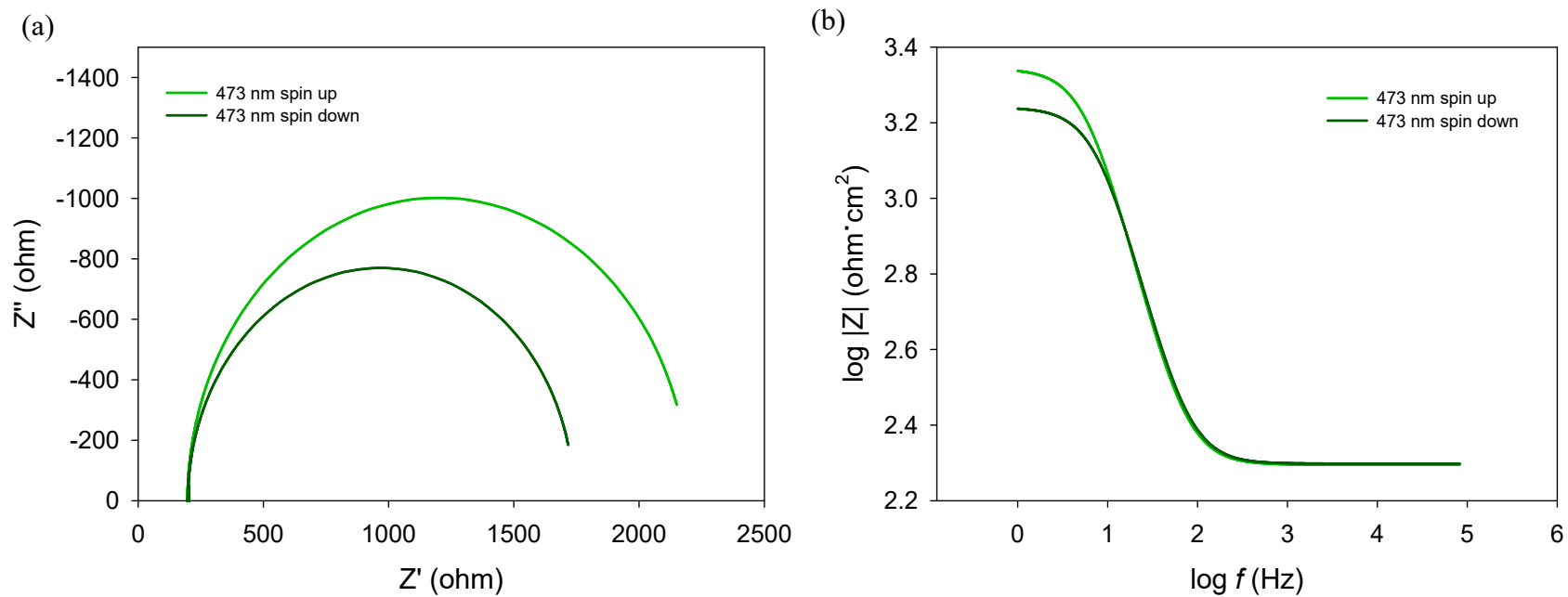
Fig. S4 Nyquist diagram (a) and Bode plots (b) of CuO-Cu$_2$O nanocubes photocathode under 473 nm laser (with $\hbar/-\hbar$ angular momentum modulation) irradiation, at 0.75 V in a two-electrode configuration in 1 M KHCO$_3$ electrolyte.
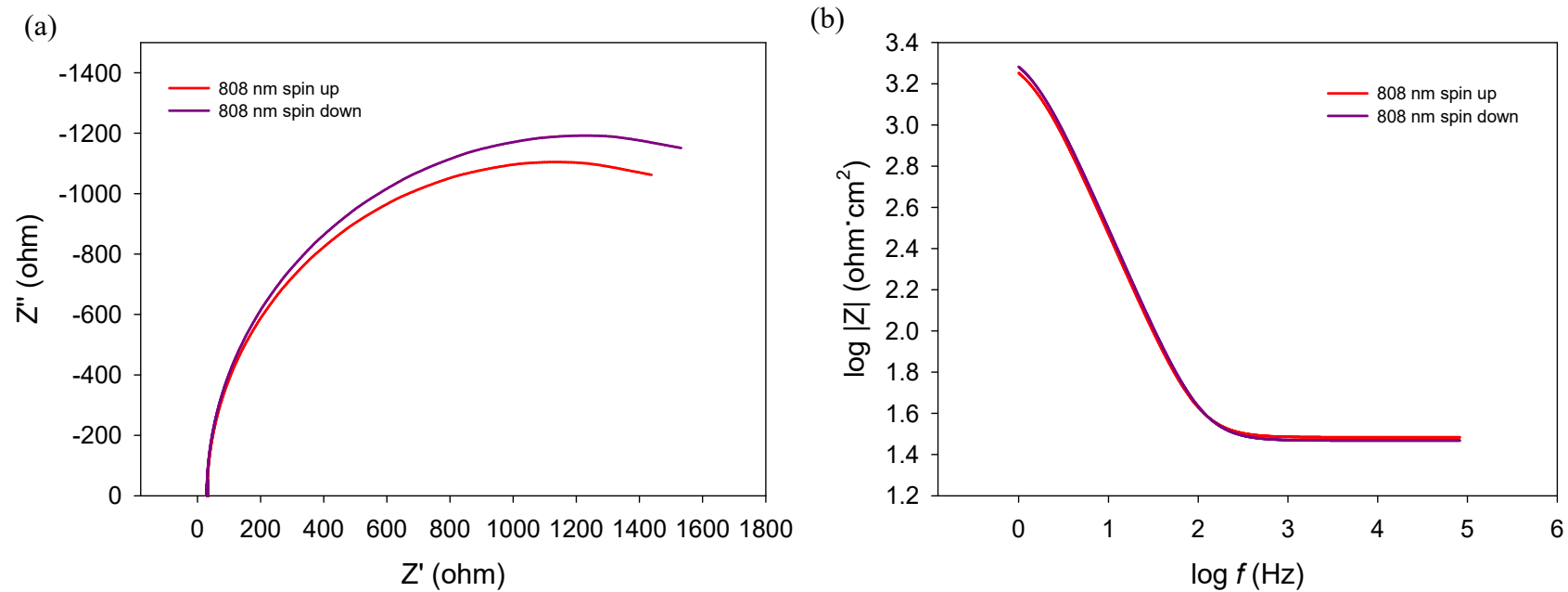
5

Fig. S5 Nyquist diagram (a) and Bode plots (b) of CuO-Cu$_2$O nanocubes photocathode under 808 nm laser (with $\hbar/-\hbar$ angular momentum modulation) irradiation, at 0.90 V in a two-electrode configuration in 1 M KHCO$_3$ electrolyte.
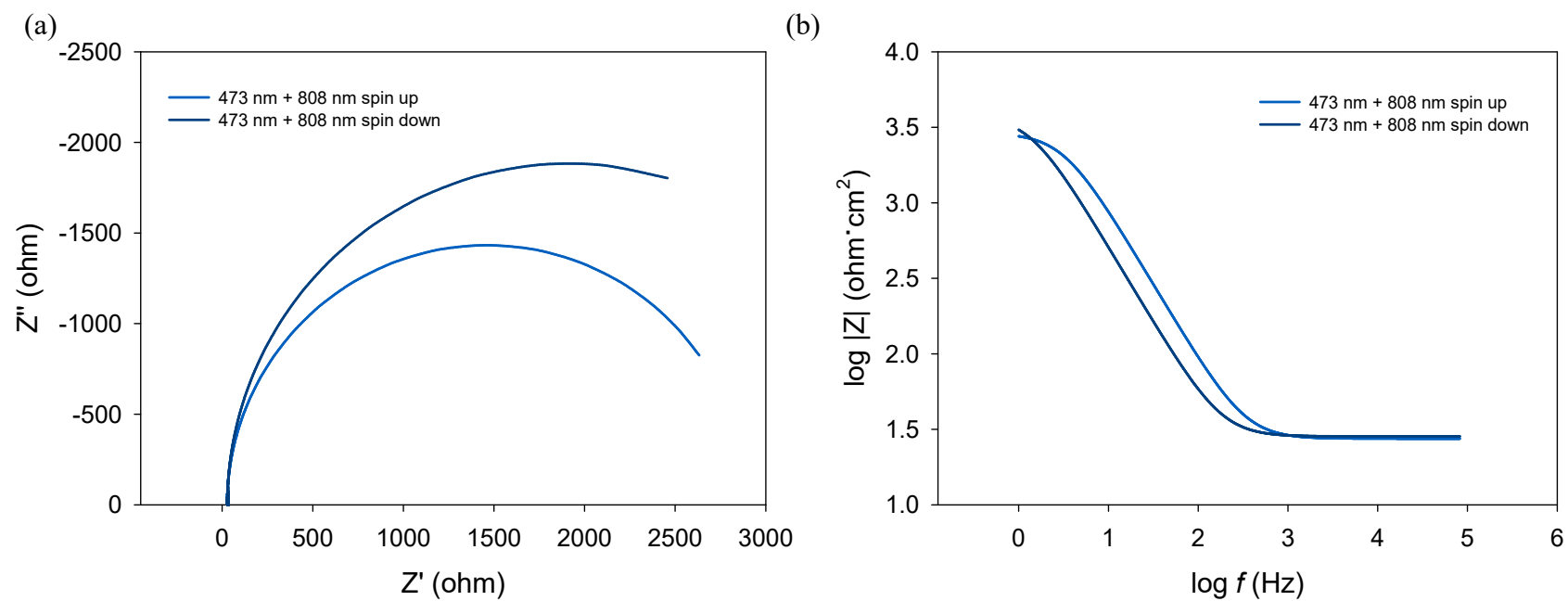
Fig. S6 Nyquist diagram (a) and Bode plots (b) of CuO-Cu$_2$O nanocubes photocathode under 473 nm laser combined with 808 nm laser (only 808 nm laser with $\hbar/-\hbar$ angular momentum modulation) irradiation, at 0.90 V in a two-electrode configuration in 1 M KHCO$_3$ electrolyte.